

WHAT IS CLAIMED IS:

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- 1 1. A device for performing sound field hearing testing, said device comprising:
- 2 a) an audio transducer for producing acoustic test stimuli to a test subject within
- 3 the direct sound field range of said audio transducer, and
- 4 b) a contactless position sensor system for measuring the position of said device
- 5 with respect to the head or part thereof of interest of said test subject,
- 6 whereby hearing evaluation of said test subject, when properly positioned relative
- 7 to said device, may be performed by said device based on said acoustic test stimuli.
- 1 2. The device of claim 1, including means for automatically determining or
- 2 adjusting characteristics of said acoustic test stimuli, including onset, amplitude and frequency
- 3 characteristics, in response to position measurements performed by said position sensor system.
- 1 3. The device of claim 1, wherein said device is constructed and adapted to be
- 2 hand held by said test subject.
- 1 4. The device of claim 1, wherein said device is configured as a wrist watch.
- 1 5. The device of claim 1, wherein said device is configured for operation by a test
- 2 operator assisting said test subject.

1           6.     The device of claim 1, including means for performing said hearing evaluation  
2     in an unaided condition in which said test subject is not wearing a hearing aid.

1           7.     The device of claim 1, including means for performing said hearing evaluation  
2     in an aided condition in which said test subject is wearing a hearing aid.

1           8.     The device of claim 7, including means for performing said hearing evaluation  
2     in said aided condition to verify functionality of said hearing aid worn by said test subject.

1           9.     The device of claim 7, including means for performing said hearing evaluation  
2     in said aided condition to adjust at least one parameter of said hearing aid.

1           10.    The device of claim 1, further comprising means for delivering at least one of  
2     said acoustic test stimuli within the soft level listening range of normal hearing individuals.

1           11.    The device of claim 10, wherein said soft level listening range is between 20 and  
2     40 dB HL.

1           12.    The device of claim 1, further comprising means for delivering at least one of  
2     said acoustic test stimuli within the comfortable level listening range of normal hearing

3 individuals.

1 13. The device of claim 12, wherein said comfortable level listening range is  
2 between 45 and 65 dB HL.

1 14. The device of claim 1, wherein said contactless position sensor system  
2 comprises at least one of an optical transducer, acoustic transducer and ultrasonic transducer.

1 15. The device of claim 1, wherein said contactless position sensor system  
2 comprises means for automatically computing the distance between said device and the head  
3 or part thereof of interest of said test subject.

1 16. The device of claim 1, wherein said contactless position sensor system  
2 comprises means for automatically determining if the device is within an operable range and  
3 orientation with respect to the head or part thereof of interest of said test subject.

1 17. The device of claim 1, wherein said contactless position sensor system  
2 comprises a transmitting transducer and a receiving transducer.

1 18. The device of claim 17, wherein said contactless position sensor system  
2 comprises means for computing the distance between the device and the head or said part

3 thereof of interest of said test subject based on the latency period between a transmitted signal  
4 emitted by said transmitting transducer and reflected signal received by said receiving  
5 transducer.

1 19. The device of claim 17, wherein said transmitting transducer and receiving  
2 transducer are combined in a unitary bidirectional transducer.

1 20. The device of claim 1, further comprising means to select from at least two  
2 types of acoustic test stimuli including speech, noise and tone types.

1 21. The device of claim 1, further comprising means to select acoustic test stimuli  
2 in at least two frequency ranges.

1 22. The device of claim 1, further comprising at least one switch for selection of at  
2 least one acoustic test stimulus.

1 23. The device of claim 1, further comprising interface means for connecting a  
2 remote instrument to said device for remotely operating said device.

1 24. The device of claim 23, wherein said remote instrument comprises a computer.

1           **25.**    The device of claim **23**, wherein said interface means comprise an electrical  
2    cable.

1           **26.**    The device of claim **23**, wherein said interface means comprise the Internet.

1           **27.**    The device of claim **23**, wherein said interface means comprise a wireless link  
2    including any of infrared, radio frequency, electromagnetic, sound, or ultrasound.

1           **28.**    The device of claim **23**, further comprising response registration means for  
2    registering test responses by said test subject and relaying said test responses to said remote  
3    instrument.

1           **29.**    The device of claim **28**, wherein said response registration means comprise at  
2    least one key.

1           **30.**    The device of claim **1**, further comprising visual status display means, including  
2    liquid crystal display (LCD) and light emitting diode (LED).

1           **31.**    The device of claim **1**, further comprising a controller.

1           **32.**    The device of claim **1**, further comprising memory for storage of data

2 representative of acoustic test stimuli.

1 33. The device of claim 1, further comprising a microphone.

1 34. The device of claim 33, wherein said microphone provides means for measuring  
2 ambient background noise, for self testing, or for self calibration of said device.

1 35. The device of claim 7, further comprising wireless remote control means for  
2 controlling or adjusting at least one parameter of said hearing aid worn by said test subject.

1 36. The device of claim 35, wherein said wireless remote control means comprise  
2 a magnet.

1 37. A hand held device for performing sound field hearing evaluation in a  
2 contactless manner with respect to a test ear of a test subject, said device comprising:

3 a) an audio transducer for delivering acoustic test stimuli to said test subject  
4 holding said device within the direct sound field range of said audio transducer,

5 b) means for selecting delivery of said acoustic test stimuli through said audio  
6 transducer at two or more intensity levels for performing one or more supra-threshold hearing  
7 measurements, and

8 c) means for selecting delivery of said acoustic test stimuli through said audio

9 transducer in at least two frequency ranges for performing hearing evaluation in at least two  
10 frequency ranges.

1 38. The hand held device of claim 37, wherein said device is configured for  
2 operation by said test subject.

1 39. The hand held device of claim 37, wherein said device is configured for  
2 operation by a test operator assisting said test subject

1 40. The hand held device of claim 37, including means for performing said hearing  
2 evaluation in an unaided condition in which said test subject is not wearing a hearing aid.

1 41. The hand held device of claim 37, including means for performing said hearing  
2 evaluation in an aided condition in which said test subject is wearing a hearing aid.

1 42. The hand held device of claim 41, including means for performing said hearing  
2 evaluation in said aided condition to verify functionality of said hearing aid worn by said test  
3 subject.

1 43. The hand held device of claim 41, including means for performing said hearing  
2 evaluation in said aided condition to adjust at least one parameter of said hearing aid.

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1           **44.**    The hand held device of claim 37, further comprising means for delivering at  
2   least one of said acoustic test stimuli within the soft level listening range of normal hearing  
3   individuals.

1           **45.**    The hand held device of claim 44, wherein said soft level listening range is  
2   between 20 and 40 dB HL.

1           **46.**    The hand held device of claim 37, further comprising means for delivering at  
2   least one of said acoustic test stimuli within the comfortable level listening range of normal  
3   hearing individuals.

1           **47.**    The hand-held device of claim 46, wherein said comfortable level listening range  
2   is between 45 and 65 dB HL.

1           **48.**    The hand held device of claim 37, further comprising a contactless position  
2   sensor system for measuring the position of said device with respect to the head or part thereof  
3   of interest of said test subject.

1           **49.**    The hand held device of claim 48, further including means for automatically  
2   adjusting the characteristics of said acoustic test stimuli, including onset, amplitude and



3 frequency, in response to position measurements performed by said contactless position sensor  
4 system.

1 50. The hand held device of claim 48, wherein said contactless position sensor  
2 system comprises at least one ultrasonic transducer.

1 51. The hand-held device of claim 48, wherein said contactless position sensor  
2 system comprises means for automatically determining if the device is within an operable  
3 distance and orientation with respect to said head or part thereof of interest of said test subject.

1 52. The hand held device of claim 48, wherein said contactless position sensor  
2 system comprises means for computing the distance between the device and said head or part  
3 thereof of interest of said test subject based on the latency period between a transmitted signal  
4 emitted by an ultrasonic transmitting transducer and reflected signal received by an ultrasonic  
5 receiving transducer.

1 53. The hand held device of claim 37, further comprising means to select from at  
2 least two types of said acoustic test stimuli including speech, noise and tone types.

1 54. The hand held device of claim 37, further comprising means to select said  
2 acoustic test stimuli in at least two frequency ranges.

1 55. The hand held device of claim 37, further comprising at least one switch for  
2 selection of said acoustic test stimuli.

1 56. The hand held device of claim 37, further comprising interface means for  
2 connecting a remote instrument for remotely operating said hand held device.

1 57. The hand held device of claim 56, wherein said remote instrument comprises a  
2 computer.

1 58. The hand held device of claim 56, wherein said interface means comprise the  
2 Internet.

1 59. The hand held device of claim 56, wherein said interface means comprise an  
2 electrical cable.

1 60. The hand held device of claim 56, wherein said interface means comprises a  
2 wireless link including any of infrared, radio frequency, electromagnetic, sound, or ultrasound.

1 61. The hand held device of claim 56, further comprising response registration  
2 means for registering test responses by said test subject and relaying said test responses to said

3 remote instrument.

1       **62.**     The hand device of claim **61**, wherein said response registration means comprise  
2 at least one key.

1       **63.**     The hand held device of claim **37**, further comprising visual status display  
2 means, including an liquid crystal display (LCD) and light emitting diode (LED).

1       **64.**     The hand held device of claim **37**, further comprising a controller.

1       **65.**     The hand held device of claim **37**, further comprising memory for storage of  
2 data representative of acoustic test stimuli.

1       **66.**     The hand held device of claim **37**, further comprising a microphone.

1       **67.**     The hand held device of claim **66**, wherein said microphone provides means for  
2 measuring ambient background noise, for self testing, or for self calibration of said device.

1       **68.**     The hand held device of claim **41**, further comprising wireless remote control  
2 means for controlling or adjusting at least one parameter of said hearing aid worn by said test  
3 subject.

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1        69.    The hand held device of claim 68, wherein said wireless remote control means  
2    comprise a magnet.

1        70.    A system for performing hearing evaluation of a test subject comprising:

2            a)    a hand held device containing an audio transducer within, said hand held device  
3    being positioned within the direct sound field range of said audio transducer and positioned in  
4    a contactless manner with respect to a test ear of said test subject,

5            b)    an auxiliary instrument operably connected to said hand held device for remotely  
6    controlling the operation of said hand held device, and

7            c)    means for selecting the delivery of acoustic test stimuli through said audio  
8    transducer at two or more intensity levels and at two or more frequency ranges.

1        71.    The system of claim 70, wherein said hand held device is independently operable  
2    as a hearing evaluator when detached from said auxiliary instrument.

1        72.    The system of claim 70, wherein said hand held device further comprises a  
2    contactless position sensor system for measuring the position of said hand held device with  
3    respect to the head or part thereof of interest of said test subject.

1        73.    The system of claim 72, including means for automatically adjusting the

2 characteristics of said acoustic test stimuli, including onset, amplitude and frequency, in response  
3 to position measurements performed by said position sensor system.

1 74. The system of claim 70, including means for performing said hearing evaluation  
2 in an unaided condition in which said test subject is not wearing a hearing aid.

1 75. The system of claim 70, including means for performing said hearing evaluation  
2 in an aided condition in which said test subject is wearing a hearing aid.

1 76. The system of claim 75, including means for performing said hearing evaluation  
2 in said aided condition to verify functionality of said hearing aid.

1 77. The system of claim 75, including means for performing said hearing evaluation  
2 in said aided condition to adjust at least one parameter of said hearing aid.

1 78. The system of claim 70, including means for programming the function or  
2 operation of said hand-held device with said auxiliary instrument according to the needs of said  
3 test subject.

1 79. The system of claim 70, wherein said hand held device further comprises  
2 response registration means for registering test responses by said test subject and relaying said

3 test responses to said auxiliary instrument.

1 80. The system of claim 79, wherein said response registration means comprise at  
2 least one key.

1 81. The system of claim 70, wherein said auxiliary instrument is a computer.

1 82. The system of claim 70, including means for remotely connecting said auxiliary  
2 instrument to said hand held device through the Internet.

1 83. The system of claim 70, wherein said auxiliary instrument is an audiometer.

1 84. A method of evaluating a test subject's hearing with a device containing a  
2 contactless position sensor system and an audio transducer, said method comprising the steps  
3 of:

4 a) measuring the position of said subject's head or part thereof of interest relative  
5 to said device with said position sensor system when said device is oriented to face said  
6 subject's head or part thereof of interest;

7 b) automatically determining any of the characteristics of acoustic test stimuli from  
8 said audio transducer, including onset, amplitude and frequency thereof, according to the  
9 measurement performed by said position sensor system; and

10 c) delivering said acoustic test stimuli to said test subject while said device is  
11 oriented toward said subject's head or part thereof of interest.

1 85. The method of claim 84, including the step of orienting said audio transducer  
2 at approximately 0° degree incidence and within a distance range of 30-60cm with respect to  
3 the forehead of said test subject, while performing said step of delivering acoustic test stimuli.

1 86. The method of claim 84, including the step of orienting said audio transducer  
2 at approximately 0° - 45° degree incidence range and within a distance range of 2-10 cm with  
3 respect to a test ear of said test subject while performing said step of delivering acoustic test  
4 stimuli, for monaural hearing evaluations.

1 87. The method of claim 84, including delivering said acoustic test stimuli in an  
2 unaided condition in which said test subject is not wearing a hearing aid.

1 88. The method of claim 84, including delivering said acoustic test stimuli in an  
2 aided condition in which said test subject is wearing a hearing aid.

1 89. The method of claim 88, including delivering said acoustic test stimuli in said  
2 aided condition to verify the functionality of said hearing aid.

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1           **90.**     The method of claim **88**, including delivering said acoustic test stimuli in said  
2 aided condition to adjust at least one parameter of said hearing aid.

1           **91.**     The method of claim **84**, wherein said device is hand held by said test subject  
2 during said hearing evaluation.

1           **92.**     The method of claim **84**, wherein said device is worn as a wrist watch by said  
2 test subject during said hearing evaluation.

1           **93.**     The method of claim **84**, wherein said device is configured to be held by a test  
2 operator assisting said subject during said hearing evaluation.

1           **94.**     The method of claim **84**, including connecting a remote instrument to said  
2 device via an interface to remotely control said device during said hearing evaluation.

1           **95.**     The method of claim **94**, including connecting said remote instrument to said  
2 device via the Internet.

1           **96.**     The method of claim **94**, wherein said remote instrument is a computer.

1           **97.**     The method of claim **94**, wherein said remote instrument is an audiometer.



2        **98.**    A method of hearing evaluation for an individual holding a hand held device  
3        containing an audio transducer for delivering acoustic test stimuli in a contactless manner and  
4        within the direct sound field range of said audio transducer with respect to a test ear of said  
5        individual, said method comprising the steps of:

- 6            a)    delivering at least two levels of said acoustic test stimuli to said test ear of the  
7        individual, and  
8            b)    delivering said acoustic test stimuli in at least two frequency ranges.

1        **99.**    The method of claim 98, including orienting said audio transducer at  
2        approximately 0° degree incidence and within a distance range of 30-60cm with respect to the  
3        forehead of said individual.

1        **100.**    The method of claim 98, including orienting said audio transducer at  
2        approximately 0° - 45° degree incidence range and within a distance range of 2-10 cm with  
3        respect to said test ear, for monaural hearing evaluations.

1        **101.**    The method of claim 98, including performing said hearing evaluation in an  
2        unaided condition in which said individual is not wearing a hearing aid.

1        **102.**    The method of claim 98, including performing said hearing evaluation in an  
2        aided condition in which said individual is wearing a hearing aid.

004001-021900-1500460

1           **103.**   The method of claim **102**, including performing said hearing evaluation in said  
2 aided condition to verify the functionality of said hearing aid.

1           **104.**   The method of claim **102**, including performing said hearing evaluation in said  
2 aided condition to adjust at least one parameter of said hearing aid.

1           **105.**   The method of claim **98**, in which a test operator holds said device while  
2 assisting said individual in said hearing evaluation.

1           **106.**   The method of claim **98**, including connecting a remote instrument to said  
2 device via an interface to remotely control said device during said hearing evaluation.

1           **107.**   The method of claim **106**, including connecting said remote instrument to said  
2 device via the Internet.

1           **108.**   The method of claim **106**, wherein said remote instrument is a computer.

1           **109.**   The method of claim **106**, wherein said remote instrument is an audiometer.